IJFSNPHT

IJBST Journal Group

ISSN: 0975 – 8712
IJFSNPHT (2016), 8(5):22-31

Production and evaluation of gluten-free noodles with high nutritional value

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ABSTRACT:
This study aimed to evaluate physiochemical characteristics, cooking quality and sensory properties of gluten-free noodles from five blends of broken rice flour, cassava flour, pumpkin powder, extruded defatted soy flour (EDSF) and xanthan. Adding of EDSF to gluten-free noodles formula increased protein content (15.57%). Adding of pumpkin powder to gluten-free noodles increased ß-Carotene and vitamin A (1295µg/100g–107.9 µg Retinol Activity Equivalent). Cooking quality of gluten-free noodles (cooking time, cooking weight and swelling) were increased but cooking loss and protein loss were decreased. Color measurement was ranged from yellow to orange yellow in all noodle products. Texture profile analysis revealed that hardness, cohesiveness, gumminess were increased .Chewiness and Springiness was recorded the highest value content in product no.3 compared with all products. Sensory evaluation revealed that product no.3 was the highest in overall acceptability for color, shininess, surface smoothness, firmness, chewiness, elasticity and taste. The study indicated the possibility of producing gluten-free noodles with high acceptable and nutritional value for celiac disease from formula no.3.

Key Words: Gluten-free noodle, Cooking quality, Physiochemical, Color, Sensory properties, Texture profile analysis

INTRODUCTION

Celiac disease is a chronic entheropathy produced by gluten intolerance, more precisely to certain proteins called prolamines, which causes atrophy of intestinal villi, malabsorption and clinical symptoms that can appear in both childhood and adulthood. These proteins are found in wheat, oat, barley and rye. The toxic fractions adopt different names, depending on the cereal: gliadin in wheat, avidin in oat, secalin in rye and hordein in barley. Prolamins of wheat, barley and rye are characterized by high proline content. These proteins, the main constituents of gluten, contain toxic sequences that can trigger celiac disease [1].

In the clinical studies was observed that this digestive systemic disease often was associated with malnutrition in patients. The intestinal lesion caused by celiac disease leads to various deficiencies of nutrients, protein, vitamins and minerals [2,3]. Some studies shown that diet based on gluten-free products is often characterized by low contents of some nutritional components especially proteins, minerals and also dietary fiber [4].

Noodles are foods with high acceptability worldwide because they are part of the diet of many populations and are relatively inexpensive and easy of preparation [5]. It noodle has been increasingly important food commodity worldwide, with annual production of 105,590 million packs in 2013, and a steady increase of 4% annually since 2010 [6]. Rice protein is considered as hypoallergenic protein. Rice flour used in manufacturing of many gluten free products such as rice noodle [7]. It is also a good raw material to design formulations without gluten, is thought that this cereal provides 20% of dietary energy supply of the world. Not only it is a rich source of energy but also is a good source of vitamin B such as thiamine, riboflavin and niacin. Besides, in consideration of the amino acid profile, while it has a high content of glutamic and aspartic acid it also has a low content of lysine which is a limiting amino acid [8].

Cassava (*Manihot esculenta*) is one of the most important crops worldwide. In Africa, most cassava that is produced is used for human food though in recent times, the industrial utilization is on the ascendency. Cassava does not contain any gluten and so if used to replace wheat flour 100%, the quality of the gluten- free product will be different. A suitable ratio for replacing wheat flour that will appeal to consumers will depend on the kind of food [9]. Cassava flour for the production of fast foods would reduce cost and enhance the production of noodles [10].

Legumes are important sources of food proteins with high content of lysine, leucine, aspartic acid, glutamic acid and arginine and they provide well balanced essential amino acid profiles when consumed with cereals and other foods rich in sulphur containing amino acids and tryptophan [11].

Soy beans are a good source of protein, saturated fat, and calcium and are high in fiber. Up to 50% of soy flour composition is proteins that lack gluten, because soybean is a leguminous plant. Due to a lack of a structural protein complex that interferes with gluten development, soy flour produces a

dense product with small air cells and is less likely to form tunnels [12].

Pumpkins (*Cucurbita sp*) are extensively grown in tropical and sub-tropical countries. Pumpkin is high in β-carotene, which gives it yellow or orange color a major source of vitamin A [13]. Consumption of foods containing carotene helps prevent skin diseases, eye disorders and cancer [14].

Hydrocolloids such as xanthan gum are substances that are used as additives for the purpose of reproducing similar viscoelastic properties to the gluten. They are water-soluble polysaccharides, with varied chemical structures that confer certain properties that make it of a suitable functional application) [15]. The characteristics of noodle products, such as color, cooking properties, texture and taste, are important factors affecting consumer acceptance and product quality [16].
The aim of this study is to produce of gluten-free noodles suitable for celiac patients rich in protein and ß-carotene from (broken rice flour, cassava flour, EDSF, pumpkin powder and xanthan). Physiochemical, Cooking and sensory evaluation was performed to assess the quality of the produced noodles.

MATERIALS AND METHODS

Materials:
Broken rice flour supplied by Rice Milling Company, Dakahlia, Egypt. Cassava was obtained from Crop Intensification Research Department, Field Crops Research Institute, ARC. Extruded defatted soybean flour (EDSF) was obtained from soy products factory, Food Technology Research Institute, Agricultural Research Center (ARC), Giza, Egypt. Pumpkin and salt obtained from local markets, Cairo, Egypt. Xanthan was obtained from Doves farm foods Co. UK. All other chemicals used were purchased from Algomhorya Company, Giza, Egypt.

Methods:
Preparation of broken rice flour:
The broken rice was directly ground into flour using the mixer grinder and sieving through 40 mesh sieve and placed on a cooling rack in refrigerator [17].

Preparation of cassava flour:
The fresh roots of cassava was washed and peeled, then the peeled roots were also washed, then cut into 7-8 chick discs and weighed, arranged randomly on the drying trays in single layers and placed in the drying machine (Hot air oven dryer) at the temperature of 65ºC for 9-10hrs. After drying, the moisture content of the cassava should be less than 8%. The next day, the cassava was heated for 1 hr to remove acquired moisture and milled using attrition milling machine into flour and sieved through a 40 mesh sieve and placed on a cooling rack in refrigerator [18].

Preparation of pumpkin powder:
The peeled pumpkin was converted into 10mm size cubes and subjected for pretreatments blanching (temperature 94ºC, time 2 min.). The pretreated cubes of pumpkin were dried for preparation of powder using vacuum dryer. Vacuum drying of pumpkin cubes was carried out at 80ºC and 700 mm Hg vacuum. The dried pumpkin was mixer grinder and sieving through an 40-mesh and placed on a cooling rack in refrigerator [19].

Preparation of gluten-free noodles:
Noodles blends shown in Table (1) were prepared by mixing both all ingredients with water warm to formulate the dough. The noodle dough were steam for seven minutes (Steam cooker).Then, noodles were making manually by (Imperia Trading S.r.I. 10098 RIVOLI (TO)-C.so Susa, 242), and finally, the noodles were dried at 60 º C in tray dryer until reaching 10% moisture content. The noodles stored at ambient temperature until analysis.

Cooking of gluten-free noodles:
Noodle samples (10g) were cooked to different times (1-10min) in 200 ml of boiling water. The noodles were than drained and weighed immediately. The cooked noodle was dried in oven at 50ºC according to [20].
Chemical composition and minerals of gluten-free noodles:

Proximate analysis including moisture, protein, lipid, ash and crude fiber were carried out according to the methods of. Carbohydrates content was calculated by difference. Magnesium, sodium, potassium, manganese, iron, calcium and zinc were determined according to [21]. Perkin Elmer (Model 3300, USA) Atomic Absorption Spectrophotometer was used to determine these minerals.

ß-carotene of gluten-free noodles:
The ß-carotene analysis was performed on samples by means of HPLC according to the method of [22]. HPLC Agilent 1200 Series equipped with quaternary pump, Auto sampler, column compartments et al 35ºC, malti ware length detector set at 330 mm 280 nm for detection of ß-carotene degaser column used for fractionation (Hyprsil ODS 250X4mm 5mm) and the flow rate of mobile phase during run was 1 ml/min. Vitamin A value calculation was performed based on vitamin A activity of the ß-carotenes according to the conversion factor provided by the [23]. Vitamin A value was expressed in retinol activity equivalents

(RAE), which represents vitamin A activity as retinol. Where, 12 μg of ß-carotene from foods are required to provide the body with 1 μg of retinol, giving dietary ß-carotene an RAE ratio of 12:1.

Total calories of gluten-free noodles:
Total calories for noodles were calculated from the following equation as reported by [24].
Energy value = 4 (g protein + g carbohydrates) + 9 (g fat).

Cooking quality of gluten-free cooked noodles:
Cooking time was determined according to [25]. Cooking weight, cooking loss and swelling were calculated by the equations according to the method described by [26]. Protein loss in water cooking was calculated to the described by [27].

Color measurement of gluten-free noodles:
Color of the noodles was measured according to the method outlined by [28] using a hand-held Chromameter (model CR-400, Konica Minolta, Japan).

Texture Profile Analysis (TPA) of gluten-free cooked noodles:

Hardness, cohesiveness, adhesiveness, gumminess, chewiness, springiness and resilience of cooked noodles were measured using Brookfield Engineering Lab. Inc., Middleboro, MA 02346-1031 USA according to [29] method 74-09.

Sensory evaluation of gluten-free cooked noodles:
Organoleptic characteristics of noodles were (Color, Shininess, Surface smoothness, Firmness, Chewiness and Taste) as the method described by [30].The maximum score of each attribute was (7) hedonic points.
Statistical analysis:
Statistical analysis was carried out according to [31]. LSD (Least significant difference) test was used to compare the significant differences between means of treatments [32].

RESULTS AND DISCUSSION
Chemical composition of gluten-free noodles
The results of the proximate analysis are presented in Table (2) the protein content was significantly increased, the highest protein value of noodle found in product no.5 (15.57g/100g) while the lowest protein value was found in noodle product no.1 (4.061 g/100g) these may be due to EDSF added by different levels. This results agreed with [33] who reported that legume flour used for formulation of pasta were rich in protein. Also, fat and ash were increased significantly in may be due to EDSF added which rich in fat and minerals. [34] showed that soybean is a very nutritious legume containing a high percentage of high quality proteins, with almost all the essential amino acids.

Data in Table (2) indicated that the fiber was increased significantly, and it was the highest content found in noodles product no.5 (2.691 g/100g) but the lowest fiber content noodle product was found in no.1 (1.504 g/100g). Also, the results in the same table increased significantly in fat, ash by increasing the level of added EDSF, but decreased significantly in total carbohydrates in the same level of added for EDSF. These results agreed with those reported by [35].

Minerals of gluten-free noodles:
Minerals analysis of gluten-free noodles from rice and cassava flour fortified with EDSF and pumpkin powder are presented in Table (3) the results indicated that, as the level of addition increased, values of minerals content in gluten-free noodles. Were increased all values of minerals in gluten-free noodles samples added with different levels of EDSF were higher than those found in products no.1.

Calcium ranged from (40.61 to 76.46 mg/100g) was found in products no.1 and product no.5, on the other hand products characterized by high content of iron. The results noticed that products no.5 contains 3.175 mg/100g as results of adding EDSF at level 20%. Results indicated products content ranged from 0.855 to 2.483 mg/100g in product no.1 and product no.5. These results are agreement with those reported by [36] who reported that the gluten-free noodles contained calcium, magnesium, iron, zinc and copper (18.96, 19.7, 2.66, 1.75 and 0.41 mg/100g) respectively.

ß-carotene, vitamin A and caloric value of gluten-free noodles:
Carotenoids have been extensively studied due to their important biological functions for humans and also as a natural pigment. Relations between carotenoid and vitamin A were found, and some of them have provitamin A activity (α-carotene, ß-carotene, γ-carotene, ß-zeacarotene and others), which could be transformed in vitamin A inside the animal organism [37].
Data in Table (4) represents ß-carotene μg/100g noodles gluten-free. It could be noticed that ß-carotene content ranged from 53.47 to 1295 μg/100g noodles, where product no.5 exhibited the highest amount of ß-carotene, while as product no.1 is lowest 53.47 this is may be due to the amounts of pumpkin powder during formulation Table (1). These results agreed with [35]. Vitamin A (retinol) is an essential nutrient needed in small amounts by

humans for the normal functioning of the visual system; growth and development; and maintenance of epithelial cellular integrity, immune function, and reproduction [38]. Table (4) represents vitamin A (µg RAE) 100g gluten-free noodles expressed as ß-carotene. As vitamin A calculations dependent on ß-carotene content; therefore, their values, followed a similar trend than that of ß-carotene. Data in the same table indicate product no.5 was contain highest value vitamin A 107.9 µg RAE, while as product no.1 was the lowest value of vitamin A 4.373 µg RAE. Provitamin A carotenoids are found in yellow vegetables. Foods containing provitamin A carotenoids tend to have less biologically available vitamin A [39]. From the above mentioned data about ß-carotene and vitamin A contents it demonstrated that the reasonable amounts of vitamin A in the resultant noodles. The results in Table (4) the caloric value of noodle product no.5 was high value (390.6 kcal/100g) compared with noodle product no.1 was the lowest value caloric value (387.5 kcal/100g), may be the noodle product no.5 was contained the highest value protein and fat. The results agreed with [40].

Cooking quality of gluten-free cooked noodles:

Cooking quality properties were of the important factors that manufacture and consumers of noodles gluten-free. Noodles quality and cooking properties are dependent on the protein-starch developed matrix [41]. Cooking behavior is universally the primary criterion of noodles quality. Cooked noodles must be firm and elastic with good surface condition, high degree of swell and low losses in cooking water [35].

The results in Table (5) indicated that the cooking time of noodle products ranged (4.0 - 6.5 min), the noodle product no.5 was the highest of cooking time (6.5 min) compared with control products (8.5 min). These result agreed with [42] who mentioned that during noodles cooking, there is competition between starch and protein for water. Legumes supplementation had increased the minimum cooking time of the resulted pasta as compared to control.

On the other hand, cooking weight or water absorption was increasing gradually in all noodles products (78.6-126.6%) compared with control product (151.4%) this may due to the EDSF added to all formula and increased of level of gelatinization starch during the manufacturing process the noodles. These result agreed with [43] who observed that higher water absorption in spaghetti blended with legume flour and concentrates.

From the same table cooking loss is decreased in all noodles products (19.6-11.5%) compared with control product which recorded (8.43%), this may be due to added EDSF added. These results agreed with [33] who reported that supplemented the pasta legumes flour decreased cooking loss. Also, the swelling was increased in all noodles (75.2–119.5%), the swelling or increase volume was high in noodles product no.5 to (119.5%) because this formula contained 20% EDSF, compared with noodle product no.1 which contained 5% EDSF. The results agreed with [44] who reported that a significant increase of volume expansion of legume supplemented pasta. [45] reported that the noodles made from rice and cassava flour, added guar gum reduce loss cooking.

Data in Table (5) the protein loss during cooking process was increased in all products (0.73-1.55%) compared with control product which recorded (1.04%), due to EDSF added.[20] who reported that the produced rice noodles increasing of cooking weight, swelling and reduced cooking loss.

Color measurement of gluten-free noodles:

Color one of the most important quality attributes of noodles product [46] Color measurements of the noodles product are illustrated in Table (6) The results indicated that supplementation with ESDF and pumpkin powder significantly decreased the lightness (L) values of the noodles product, where product no.1 recorded the highest value, while as product no.5 recorded the lowest value. The redness (a) values of the noodles product significantly increased in noodles product no.5 (7.452) with compared noodles product no.1 (2.152). Regarding yellowness (b) values, supplementation with EDSF significantly increased the yellowness of the noodles product. Where, product no.5 recorded the maximum b value. In contrast, product no.1 recorded the minimum b value. Like yellowness value, color saturation value (c) of noodles product no.5 (31.05) was found to be the highest value. Besides, supplementation with EDSF and pumpkin powder in noodles product no.5 (76.13) had the lowest hue angle values, while as noodles product no.1 (85.35) had the highest hue angle values. The results in Table (4) showed that the color of noodles product were noodles product no.1 (yellow), noodles product no.2 (yellow), noodles product no.3(yellow), noodles product no.4 (orange yellow) and noodles product no.5 (orange yellow) respectively. These results are in agreement with those reported by [47, 48, 49, 50].

Texture profile analysis of gluten-free cooked noodles:

Texture analysis is primarily concerned with measurement of the mechanical properties of a product, often a food product, as they relate to its sensory properties detected by humans via applying controlled forces to the product and recording its response in the form of force, deformation and time. Texture measurements can be very valuable for the quality control and process optimization as well as for the development of new products with desirable properties and characteristics. Determination of the textural parameters after noodle cooking is of great importance from the point of product acceptability by the consumers. These can be divided into the primary parameters of hardness, cohesiveness, springiness and adhesiveness, the secondary parameters factorability, chewiness and gumminess [51].

Table (7) presents texture profile analysis results for the noodle products. The same table indicates measured hardness showed that was decrease of all noodles products is may be due to the effect of EDSF and pumpkin powder during formulation Table (1). [52] reported that higher fiber and protein content of the non gluten flours which helps retaining the absorbed water after cooking. This can also be attributed to added gums which increases the rehydration rate of pasta upon cooking. [53] also reported that noodles from soy flour had significantly low hardness than other blends.

Cohesiveness quantifies the internal resistance of food structure. Briefly, cohesiveness is the ability of a material to stick to itself [54]. The texture profile analysis results showed that cohesiveness values decrease in noodle products (no.2, no.3, no.4 and no.5) compared noodles product no.1. [55] reviewed that dough's produced from gluten free formulations lack cohesive and elastic characteristics as obtained from wheat flour, because of the absence of gluten.

Gumminess is the product of hardness and cohesiveness. Chewiness represents the amount of energy needed to disintegrate a food for swallowing. Our present findings are in accordance with [54], who stated that both, gumminess and chewiness is parameters dependent on firmness; therefore, their values followed a similar trend than that of firmness. Texture profile analysis results showed a significant decrease in gumminess in all noodles products, but it was found gumminess was the highest in noodle products no.1 (2017 g) compared the lowest is noodles product no.5 (1432 g).

Chewiness which is related to the elastic strength of the protein matrix was highest for pasta. As cooking time proceeded chewiness of all pasta types decreased dramatically due to possible break down of gluten network and leaching of starch to cooking water [52]. The result in the same table, the chewiness high in noodle product no.3 (1456g) and then fall to (801g) in noodle product no.5.

Adhesiveness or stickiness is related with the amount of starch and starch gelatinization. In the early stages of cooking adhesiveness values were found to be higher and it decreased as cooking time proceeded [52]. Results in the same table showed significant decrease in adhesiveness in all noodle products, due to EDSF and pumpkin powder added [56] reported that the uniformity of dry pasta starts to change by the diffusion of water from outside to the core. Closer to the surface of the spaghetti strand the changes are more drastic, starch granules are no longer intact as in the core and protein matrix starts to break down due to denaturation. Even the gluten matrix is still elastic enough in the center. [53] reports that noodles from soy flour had significantly low hardness, chewiness and adhesiveness than other blends.

Springiness measures elasticity by determining the extent of recovery between the first and second compression. Resilience is the ratio of recoverable energy as the first compression is relieved [57]. The results showed the noodles products no.3 was the highest (0.85) compared with noodles product no.1 was the lowest (0.49). In overall, as hardness, cohesiveness, gumminess and springiness were decreased in all noodles products, due to the effect of EDSF added.

Sensory evaluation of gluten-free cooked noodles:
Among all sensory attributes, yellow color, shininess, surface smoothness, firmness, chewiness, elasticity and taste can be considered as positive attributes; these indicate better pasta quality as higher sample values, the result agreed with [30]. Sensory evaluation of cooked noodles was showed Table (8) from these data it could be observed that significant difference of yellow color in all samples cooked noodle. The lowest value of yellow color was 3.95 in noodles products no.1. Cooked noodles products (no.2, no.3, no.4 and no.5) have better color compared with noodle products no.1due to added pumpkin powder. These result agreed with [58] who indicated that the use of pumpkin powder substituted for food products improved their yellow color and β-carotene content, and would be accepted by consumers.

On the other hand, no significant differences for shininess. Surface smoothness was the lowest value in (15 and 20%) EDSF (5.35 and 5.25). No significant differences between firmness and chewiness of cooked noodle products contained EDSF up to 10%, but increased in EDSF (15 and 20%) have lower values compared to other samples. From this table it could be observed that elasticity recorded no significant values in all cooked noodles treatments and control. While taste recorded the lowest value 5.20 for cooked noodles no.1 compared to the other samples. These result agreed with [59] who reported that EDSF improves firmness, pliability and texture, facilitates cleaner, smoother slicing, may impart antioxidant effects and improves nutritional value. Results in Table 8 indicate the noodle product no.3 was the highest score of all sensory attributes at the level 10% EDSF compared with all noodles products.

Table 1: Formulas of gluten-free noodles

Ingredients (gm)	Noodles formulas				
	(1)	(2)	(3)	(4)	(5)
Broken rice flour	50	50	50	50	50
Cassava flour	50	50	50	50	50
EDSF	-	5	10	15	20
Pumpkin powder	-	20	20	20	20
Xanthan	0.1	0.1	0.1	0.1	0.1
Salt	1.0	1.0	1.0	1.0	1.0
Warm water (ml)	50	55	60	65	70

EDSF: Extruded defatted soy flour

Table 2: Chemical composition of gluten-free noodles (g/100g) on dry weight basis

Noodles products	Protein	Fat	Ash	Fiber	T.C.
(1)	4.061±0.13^{e}	0.633±0.03^{e}	1.301±0.05^{e}	1.504±0.07^{e}	91.40±1.56^{a}
(2)	7.680±0.18^{d}	0.983±0.02^{d}	1.908±0.03^{d}	2.194±0.04^{d}	87.54±1.21^{b}
(3)	9.783±0.69^{c}	1.210±0.04^{c}	2.123±0.01^{c}	2.340±0.02^{c}	83.90±1.15^{c}
(4)	13.38±0.26^{b}	1.435±0.03^{b}	2.379±0.02^{b}	2.482±0.05^{b}	80.78±1.25^{d}
(5)	15.57±0.42^{a}	1.661±0.05^{a}	2.485±0.04^{a}	2.691±0.08^{a}	78.35±1.31^{e}

T.C.: Total carbohydrates
Data are presented as means ± SDM (n=3) & Means within a column with different letters are significantly different at ($P \leq 0.05$)

Table 3: Minerals of gluten-free noodles (mg/100g)

Minerals	Noodles products				
	(1)	(2)	(3)	(4)	(5)
Calcium	40.61±1.26^{e}	51.73±1.24^{d}	63.84±1.12^{c}	70.63±1.65^{b}	76.42±1.52^{a}
Sodium	50.74±1.14^{e}	55.31±1.14^{d}	59.53±1.31^{c}	67.52±0.21^{b}	71.63±0.17^{a}
Potassium	110.7±0.14^{e}	112.1±0.15^{d}	117.2±0.13^{c}	121.4±0.15^{b}	124.3±0.21^{a}
Manganese	4.806±0.05^{e}	5.325±0.03^{d}	5.708±0.02^{c}	6.618±0.01^{b}	7.624±0.02^{a}
Iron	1.195±0.06^{e}	1.712±0.05^{d}	2.568±0.06^{c}	2.874±0.04^{b}	3.175±0.03^{a}
Zinc	0.855±0.01^{e}	1.422±0.02^{d}	1.967±0.05^{c}	2.196±0.02^{b}	2.483±0.01^{a}

Data are presented as means ± SDM (n= 3) & Means within a raw with different letters are significantly different at ($P \leq 0.05$)

Table 4: ß-carotene, vitamin A and caloric value of gluten-free noodles

Noodles products	ß-carotene (µg/100g)	Vitamin A (µg RAE)* (as ß-carotene)/100g	Caloric value (kcal/100g)
(1)	53.47	4.373	387.5
(2)	1125	93.75	389.7
(3)	1187	98.92	385.6
(4)	1234	102.8	389.5
(5)	1295	107.9	390.6

*Retinol Activity Equivalent (RAE). 1 RAE = 1 µg retinol, 12 µg β-carotene, whereas the RAE for preformed vitamin A is the same as Retinol Equivalent (RE).

Table 5: Cooking quality of gluten-free cooked noodles

Noodles products	Cooking quality				
	Cooking time (Min)	Cooking weight (%)	Cooking loss (%)	Swelling (%)	Protein loss (%)
(1)	4.0±0.5^{f}	78.6±0.36^{f}	19.6±0.21^{a}	75.2±0.76^{f}	0.73±0.02^{f}
(2)	4.5±0.5^{e}	92.5±0.15^{e}	15.6±0.32^{b}	84.7±0.57^{e}	1.12±0.02^{d}
(3)	5.0±0.5^{d}	105.4±0.4^{d}	14.5±0.26^{c}	94.7±0.38^{d}	1.32±0.01^{c}
(4)	5.5±0.5^{c}	117.5±0.3^{c}	12.6±0.25^{d}	104.3±0.5^{c}	1.47±0.02^{b}
(5)	6.5±0.5^{b}	126.6±0.2^{b}	11.5±0.13^{e}	119.5±0.3^{b}	1.55±0.01^{a}
Control	8.5±0.5^{a}	151.4±0.7^{a}	8.43±0.12^{f}	144.6±0.4^{a}	1.04±0.03^{e}

Data are presented as means ± SDM (n=3) &Means within a column with different letters are significantly different at ($P \leq 0.05$)

Table 6: Color measurement of gluten-free noodles *

Prosperities	Noodle products				
	(1)	(2)	(3)	(4)	(5)
L	71.34±0.04^{a}	68.73±0.02^{b}	66.14±0.03^{c}	63.45±0.05^{d}	60.34±0.03^{e}
a	2.152±0.02^{e}	3.941±0.05^{d}	4.853±0.02^{c}	6.161±0.04^{b}	7.452±0.03^{a}
b	26.53±0.02^{e}	27.11±0.04^{d}	27.85±0.03^{c}	28.93±0.06^{b}	30.15±0.05^{a}
c	26.64±0.03^{e}	27.42±0.02^{d}	28.27±0.06^{c}	29.55±0.04^{b}	31.05±0.02^{a}
h	85.35±0.02^{a}	81.64±0.03^{b}	80.14±0.05^{c}	78.04±0.04^{d}	76.13±0.02^{e}
Color	Yellow	Yellow	Yellow	Orange yellow	Orange yellow

***L** (lightness with L = 100 for lightness, and L = zero for darkness), a [(chromaticity on a green (−) to red (+)], b [(chromaticity on a blue (−) to yellow (+)], c (color saturation), h [(hue angle where 0˚ = red to purple, 90˚ = yellow, 180˚ = bluish to green and 270˚ = blue scale
Data are presented as means ± SDM (n= 3) &Means within a column with different letters are significantly different at ($P \leq 0.05$)

Table 7: Texture profile analysis (TPA) of gluten-free cooked noodles

Parameters	Noodles products				
	(1)	(2)	(3)	(4)	(5)
Hardness (g)	2293	2178	2090	1982	1837
Cohesiveness	0.88	0.85	0.82	0.79	0.78
Gumminess (g)	2017	1851	1713	1565	1432
Chewiness (g)	988	1443	1456	1064	801
Adhesiveness (gs^{-1})	41.0	35.0	32.0	30.0	25.0
Springiness	0.49	0.78	0.85	0.68	0.56
Resilience	0.3	0.12	0.08	0.07	0.06

Table 8: Sensory evaluation of gluten-free cooked noodles

Characters	Noodles products					
	Control	(1)	(2)	(3)	(4)	(5)
Color	6.54±0.51^{a}	3.95±1.17^{c}	5.90±0.87^{ab}	6.45±0.79^{a}	5.45±0.76^{b}	5.45±1.16^{b}
Shininess	6.40±0.55^{a}	5.95±1.01^{ab}	6.00±0.94^{ab}	6.35±0.81^{a}	5.65±1.00^{ab}	5.30±1.23^{b}
S.S	7.00±0.00^{a}	6.50±0.53^{a}	6.00±0.91^{ab}	6.20±0.67^{a}	5.35±1.06^{bc}	5.25±0.63^{c}
Firmness	6.30±0.44^{a}	6.40±0.84^{a}	6.25±0.63^{a}	6.20±0.58^{a}	5.35±0.67^{b}	5.35±1.05^{b}
Chewiness	6.10±0.55^{a}	5.90±0.87^{ab}	6.40±0.52^{a}	6.45±0.44^{a}	5.35±0.85^{b}	5.35±0.67^{b}
Elasticity	6.20±0.84^{a}	5.90±1.37^{a}	5.70±0.82^{a}	6.10±0.77^{a}	5.45±0.49^{a}	5.45±0.55^{a}
Taste	6.70±0.45^{a}	5.20±1.54^{b}	6.05±0.83^{ab}	6.30±0.67^{a}	5.65±0.78^{ab}	5.50±0.97^{ab}

S.S.: Surface smoothness
Data are presented as means ± SDM (n= 3) & Means within a raw with different letters are significantly different at ($P \leq 0.05$)


Noodles No.1


Noodles No.2


Noodles No.3


Noodles No.4

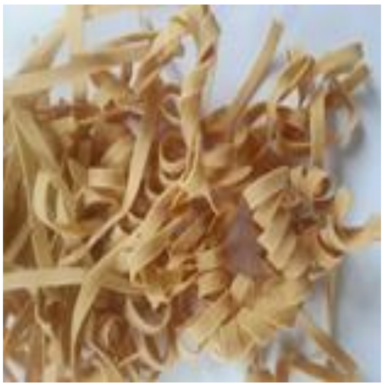
Noodles No.5

Fig 1. gluten-free noodles

CONCLUSION

The formulation of gluten-free products includes the use of different starches and flours, such as broken rice and cassava flour. Noodles products have been fortified to enhance their nutritional properties with supplements from various high protein sources such as EDSF good additives to noodles as judged by color, cooking loss. Pumpkin powder is high in β-carotene, which gives it yellow or orange color and is a major source of vitamin A. Sensory evaluation revealed that the high acceptance of products were found in EDSF at level of addition 10% and pumpkin powder at level 20%. Finally, this study found that utilize of broken rice flour, cassava flour, xanthan, EDSF and pumpkin powder give good high quality noodle products suitable for individual with celiac disease.

CONFLICT OF INTEREST

The authors declare that this study has no conflict of interest

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